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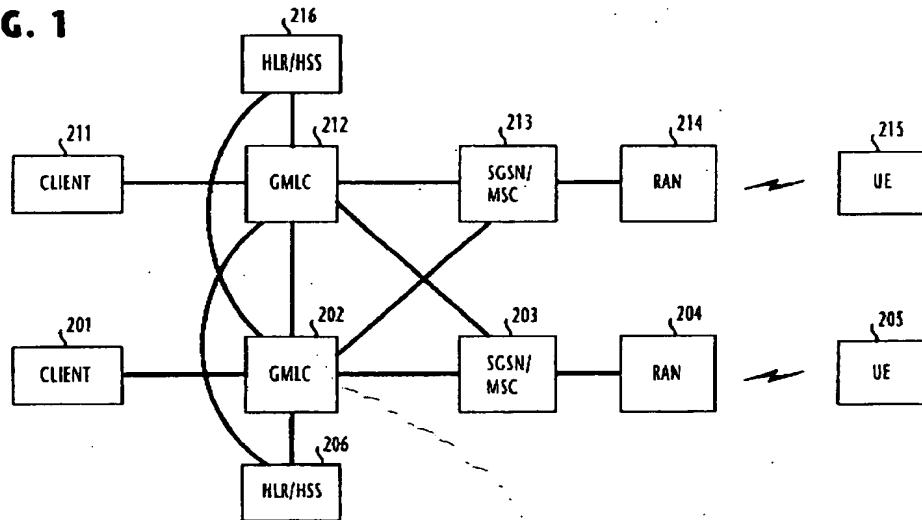
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(54) Location system with enhanced security

(57) In a location system, gateways maintain privacy settings of mobile terminals. On receiving a location request from a client terminal, each gateway determines which of the gateways maintains the privacy settings of a target mobile terminal specified in the request, and transmits the location request to a gateway if the latter maintains the privacy settings of the specified target mobile terminal. The gateway performs a first privacy check

on a location request received either from the client terminal or from other gateway using the privacy settings of the target mobile terminal, transmits the request to a positioning system to obtain a measurement result indicating the location of the target mobile terminal if the request conforms to the privacy settings, and performs a second privacy check on the measurement result using the privacy settings. A result of the second privacy check is then communicated to the client terminal.

FIG. 1



LEGEND: GMLC = GATEWAY MOBILE LOCATION CENTER

HLR/HSS = HOME LOCATION REGISTER/HOME SUBSCRIBER SERVER

SGSN/MSC = SERVING GPRS (GENERAL PACKET RADIO SERVICE) SUPPORT NODE/MOBILE SERVICES SWITCHING CENTER

RAN = RADIO ACCESS NETWORK

UE = USER EQUIPMENT

Description

[0001] The present invention relates generally to mobile communication systems, and more specifically to a location system for providing information services to clients as to the location of user equipment (UE) terminals.

[0002] As a value-added feature of mobile communication service, location information service is an important subject currently being under study by the Third Generation Partnership Program (3GPP) to enhance the functionality of mobile terminals. The 3GPP Technical Specification 23.271 v.5.1.0, "Functional stage 2 description of LCS", December 2001 (hereinafter Document 1), is a current standard that specifies particulars of location information services. Since information as to the location of a mobile terminal is very sensitive to the user and must be protected, mobile communication networks are provided with sophisticated privacy protection functionality which imposes restriction control on accesses according to end-user's privacy settings.

[0003] The privacy settings as requested by mobile users are of two types. One is a type of information which can be determined at the time a location request is sent to the location system, such as the name of clients or service classes. The other is of a type of information which can be determined only at the time after the location information of the target mobile terminal is obtained, such as the geographic location of a target user equipment or the time of day the location information is obtained from the location system.

[0004] The 3GPP location information system, as described in Document 1 and shown in Fig. 12, is made up of client terminal 101, GMLC (Gateway Mobile Location Center) 102, SGSN/MSC (Serving General packet radio service Support Node/MobileServiceSwitching-Center) 103, local wireless network known as RAN (Radio Access Network) 104 and UE (User Equipment) terminal 105 connected to the RAN via wireless link. HLR/HSS (Home Location Register/Home Subscriber Server) 106 is connected to the GMLC 102 as a database for holding the identity of the RAN to which UE terminals are connected.

[0005] When a location request is sent to the system for a target UE terminal, the SGSN/MSC 103 that manages the RAN to which the UE terminal is connected takes the responsibility for protecting the privacy of the terminal. Client terminals which are authorized to access a UE terminal are registered in the location system in advance by the user of the UE terminal in order to protect the user from unauthorized accesses.

[0006] However, a need has recently arisen to provide versatile protection functionality, the current client-based scheme is not sufficient to fulfil the need. To implement a versatile protection mechanism for a given service area of the current 3GPP system, it would be necessary to extend the privacy check functionality of all SGSN/MSC systems that exist in that service area. However, the introduction of such a versatile protection

mechanism in the SGSN/MSC systems would be too costly if future expansion and system growth are to be taken into account. It is desired that a versatile privacy check mechanism should be provided in a system other than SGSN/MSC. Additionally, a desirable feature of the versatile protection mechanism is to protect UE terminals roaming in an external network from unauthorized access from client terminals of the external network.

[0007] With the background just described, an enhanced privacy check mechanism has been proposed in Chapter 7 of 3GPP Technical Report 23.871 v1. 1.0, "Enhanced support for User Privacy in location services", tdoc S2-020316, January 23, 2002 (hereinafter Document 2).

[0008] However, privacy items protected by the enhanced mechanism relate only to those associated with the time at which location request is made and sent to the location service system. No consideration is taken of those privacy items which can be determined only at the time after the location information of the target mobile terminal is obtained. Furthermore, while Document 2 proposes a scheme for serving requests from clients of a remote network to UE terminals of a home network through collaborations between the networks, specific functions and responsibilities are yet to be determined.

[0009] It is therefore a primary object of the present invention to provide a method and a system for securing location-service privacy protection not only for privacy parameters known at the time a location request is made, but those privacy parameters which can be determined only at the time after the location information of the target mobile terminal is obtained.

[0010] It is another object of the present invention to provide a method and a system for securing location-service privacy protection for location requests from clients of an external network requesting the location of UE terminals of a home network by allocating functions and responsibilities to gateways of the networks.

[0011] It is a further object of the present invention to provide a method and a system for securing location-service privacy protection for an event-triggered location request which may encounter privacy settings which have already been altered during the time prior to the occurrence of the event.

[0012] According to a first aspect, the primary object of the present invention is obtained by a location system comprising a plurality of mobile terminals, a client terminal for transmitting a location request specifying a target mobile terminal, a positioning system accessible to the mobile terminals for producing location information in response to a location request, and a gateway for holding privacy settings of the mobile terminals, performing a first privacy check on a location request of the client terminal using the privacy settings of a target mobile terminal specified by the request, transmitting the request to the positioning system to obtain location information if the request conforms to the privacy settings, and performing a second privacy check on the location informa-

tion using the privacy settings of the target mobile terminal.

[0013] According to a second aspect, the present invention provides a location system comprising a plurality of mobile terminals, a plurality of client terminals for transmitting a location request specifying a target mobile terminal, a positioning system accessible to the mobile terminals for producing location information of the mobile terminal in response to a location request, and a plurality of gateways for maintaining privacy settings of the mobile terminals. On receiving a location request from a client terminal, each gateway determines which of the gateways maintains the privacy settings of the specified target mobile terminal, and transmits the location request to a gateway if this gateway maintains the privacy settings of the specified target mobile terminal. Each gateway performs a first privacy check on a location request received either from the client terminal or from other gateway using the privacy settings of the specified target mobile terminal maintained in the gateway, transmits the request to the positioning system to obtain location information of the mobile terminal if the request conforms to the privacy settings, and performs a second privacy check on the location information using the privacy settings maintained in the gateway.

[0014] According to a further aspect, each gateway is arranged to transmit an event-triggered location request to the positioning system to obtain location information of the target mobile terminal if a specified event occurs with respect to the target mobile terminal, perform the second privacy check on the location information if the privacy settings of the target mobile terminal is not altered before the location information is obtained from the positioning system, and transmit a cancellation request to the positioning system if the privacy settings of the target mobile terminal is altered before the location information is obtained from the positioning system.

[0015] The present invention will be described in detail further with reference to the following drawings, in which:

Fig. 1 is a block diagram of a location system of the present invention for implementing location services with enhanced support for user privacy in a multi-network environment;

Figs. 2A, 2B and 2C are a flowchart of the operation of GMLCs of Fig. 1 when a location request is received from the associated client terminal;

Fig. 3 is a sequence diagram for illustrating a series of events that occur across the location system when a home network client is requesting the location information of a UE terminal from the home network;

Fig. 4 is a sequence diagram for illustrating a series of events that occur across the location system when a home network client is requesting the location information of a UE terminal from an external network;

Fig. 5 is a flowchart of the operation of a home GMLC when a location request is repeatedly transmitted from a requesting GMLC to the home GMLC according to a modified embodiment of the present invention;

Fig. 6 is a sequence diagram of a series of events that occur across the location system when the routine of Figs. 2A, 2B and 5 is executed;

Figs. 7A and 7B are a flowchart of the operation of a remote GMLC when a location information request is repeatedly transmitted from the remote GMLC to an SGSN/MSC according to a further modification of the present invention;

Fig. 8 is a sequence diagram of a series of events that occur across the location system when the routine of Figs. 2A, 7A and 7B is executed;

Fig. 9 is a flowchart of the operation of a remote GMLC when an event-triggered location request is sent to an SGSN/MSC to obtain location information of a target UE terminal when an event occurs in the target UE terminal;

Figs. 10A and 10B are sequence diagrams of a series of events that occur in the system when the routine of Figs. 2A, 2C and 9 is executed;

Fig. 11 is a block diagram of a modified location system of the present invention; and

Fig. 12 is a block diagram of a prior art location system.

[0016] Referring now to Fig. 1, there is shown a location system of a mobile multi-network environment according to the present invention. The location service system is comprised of a plurality of GMLCs (gateway mobile location centers) 202 and 212 to which client terminals 201 and 211 are respectively connected to send their location requests. GMLC 202 is connected to SGSN/MSCs (serving GPRS support node/mobile service switching centers) 203 and 213. GMLC 212 is also connected to both SGSN/MCSs 203, 213. Further, both

GMLCs are interconnected to each other to send a location request to the other GMLC when the request is for a UE terminal of the external network. RANs 204 and 214 are connected to SGSN/MSCs 203, 213, respectively. UE terminals 205 and 215 are connected via a wireless link to the RANs 204, 214, respectively. For simplicity, only one RAN is shown connected to each SGSN/MSC as a representative of a number of RANs managed by the associated SGSN/MSC. Identification data of SGSN/MSC 203, which manages RAN 204 where UE terminal 205 is connected, is maintained in an HLR/HSS (home location register/home subscriber server) 206 and the identification data of SGSN/MSC 213, which manages RAN 214 where UE terminal 215 is connected, is maintained in an HLR/HSS 216. The privacy settings of UE terminal 205 are stored in GMLC 202 and the identification data of GMLC 202 is stored in HLR/HSS 206. The privacy settings of UE terminal 215 are stored in GMLC 212 and the identification data

of GMLC 212 is stored in HLR/HSS 216. The privacy settings of UE terminal 205 are stored in GMLC 202 and the identification data of GMLC 202 is stored in HLR/HSS 206. The privacy settings of UE terminal 215 are stored in GMLC 212 and the identification data

of GMLC 212 is stored in HLR/HSS 216. The privacy settings of UE terminal 205 are stored in GMLC 202 and the identification data of GMLC 202 is stored in HLR/HSS 206. The privacy settings of UE terminal 215 are stored in GMLC 212 and the identification data

of GMLC 212 is stored in HLR/HSS 216. The privacy settings of UE terminal 205 are stored in GMLC 202 and the identification data of GMLC 202 is stored in HLR/HSS 206. The privacy settings of UE terminal 215 are stored in GMLC 212 and the identification data

of GMLC 212 is stored in HLR/HSS 216. Each of the HLR/HSS 206 and 216 is connected to both GMLCs 202, 212.

[0017] Each of the GMLCs 202 and 212 operates according to a flowchart shown in Figs. 2A, 2B and 2C.

[0018] In response to a location request either from a client terminal or other GMLC (step 301, Fig. 2A), the GMLC of each network (hereinafter requesting GMLC) proceeds to step 302 to check to see if the location request is from a client terminal or from other GMLC. If it is determined that the location request is from a client terminal, flow proceeds from step 302 to step 303 to verify the authentication of the requesting client terminal. If the verification fails, flow proceeds to step 327 (Fig. 2C) to send an error message to the requesting client terminal.

[0019] If the client terminal is verified (step 304), flow proceeds to step 305 to determine whether a home GMLC that manages the privacy information of the target UE is already known. If the requesting GMLC is the privacy management node of the target UE terminal, the decision at step 305 is affirmative and flow proceeds to step 308.

[0020] If the decision at step 305 is negative, flow proceeds to step 306 to send an enquiry message to the HLR/HSS of the network which the target UE belongs to, in order to obtain information as to the identity of a home GMLC that maintains the privacy information of the target UE. If the identity of the home GMLC is obtained from the HLR/HSS, the decision at step 307 is affirmative and flow proceeds to step 308 to determine whether the received GMLC identity indicates that the requesting GMLC is the home GMLC of the target UE.

[0021] If it is determined, at step 308, that the requesting GMLC is the home GMLC, the requesting GMLC proceeds to step 311 (Fig. 2B) to perform a privacy check on the location request based on the privacy settings of the target UE terminal and determines whether the location request received from the client terminal conforms to the privacy settings of the UE terminal (step 312). If the location request conforms to the privacy settings of the target UE, the home GMLC proceeds from step 312 to step 313 to send an enquiry message to the HLR/HSS system for requesting the identity of SGSN/MSC that manages the target RAN.

[0022] If the UE terminal 205 is the target UE, the identity of SGSN/MSC 203 will be received (step 314) and the home GMLC proceeds to step 315 to transmit a location request to the SGSN/MSC. In response to the location request from the home GMLC, the SGSN/MSC begins to process location estimation by collaborating with the RAN and the target UE terminal and transmits the location information of the target UE terminal to the home GMLC.

[0023] When the home GMLC receives a response message from the SGSN/MSC (step 316), it proceeds to step 317 to process the received location information according to the privacy settings of the target UE terminal 205 and performs a privacy check on the processed location information. At step 318, the processed location information is checked against the privacy settings of the target UE for conformance. If the processed location information conforms to the privacy settings of the target UE, flow proceeds from step 318 to step 321 (Fig. 2C) to check to see if the location request originally received at step 301 is from other GMLC. If the location request initially received at step 301 is from the client terminal, the decision at step 321 is negative and the home GMLC proceeds to step 322 to process the location information according to the preference settings specified by the client terminal. If the client wishes to receive the location information as address information, this data processing is a process of format conversion from geographical coordinate system (latitude and longitude) to address information on a geographic map. At step 323, the location information is transmitted from the local GMLC to the requesting client terminal.

[0024] If a location request the home GMLC has received is from a remote GMLC, the decision at step 302 is affirmative and flow proceeds to step 309 to verify the authentication of this GMLC. If the remote GMLC is not verified at step 310, an error message is sent to the remote GMLC (step 327). If the remote GMLC is verified, flow proceeds to step 311 to perform a privacy check on the received location information as described above.

[0025] If the requesting GMLC is not the UE-privacy management node, the decision at step 308 is negative, and flow proceeds to step 325 (Fig. 2C) to send a location request to the home GMLC and waits for location information from the home GMLC at step 326. When location information is received from the home GMLC, flow proceeds from step 326 to step 322 to process the location information according to the preference settings of the client terminal and transmit the processed location information to the client terminal. If no location information is received, flow proceeds from step 326 to step 327 to send an error message to the client terminal.

[0026] If the decision at steps 312, 314, 316 and 318 is negative, flow proceeds to step 327 to send an error message to the requesting source.

[0027] Therefore, if the client terminal 201 requested the location information of the UE terminal 205, the GMLC 202 will receive a location request 401 (see Fig. 3) from the client terminal 201 (steps 301 to 304). If the GMLC 202 does not know the identity of the GMLC which manages the privacy settings of the target UE, the decision at step 305 will be negative and the GMLC 202 sends an enquiry message 402 at step 306 to the HLR/HSS 206. The GMLC 202 receives, at step 307, a response message 403 from the HLR/HSS 206, indicating that GMLC 202 is the privacy management node of the target UE terminal 205. Thus, the GMLC 202 makes an affirmative decision at step 308 and performs a privacy check 404 at step 311. If the GMLC 202 knows that it is the managing node of the privacy settings of the target UE, the decision at step 305 is affirmative, steps

306 and 307 will be skipped.

[0028] Once the privacy check 404 has been performed (step 311) and conformance indicated (step 312), an enquiry message 405 is sent (step 313) to the HLR/HSS 206 for requesting it to respond with a message 406 containing the identity of an SGSN/MSC that manages the RAN 204 where the target UE is connected (step 314). A location request 407 is sent from the GMLC 202 (step 315) to the SGSN/MSC 203. In response to the location request 407, the SGSN/MSC 203 begins to process location estimation by collaborating with the RAN 204 and the target UE terminal 205 (as indicated by an event 408) and transmits the location information of the target UE 205 as a response message 409 to the GMLC 202. The location information contained in the response message 409 is processed according to the UE's privacy settings. Privacy check 410 is then performed on the processed location information at step 317 to check to see if it conforms to the UE's privacy settings (step 318). The GMLC 202 processes the location information according to the preference settings of the client terminal 201 (step 322). The processed location information is transmitted in a message 411 to the client terminal 201.

[0029] Therefore, if the client terminal 211 requested the location information of the UE terminal 205, the GMLC 212 will receive a location request 501 (see Fig. 4) from the client terminal 211 (steps 301 to 304). If the GMLC 202 has no knowledge of the identity of the GMLC which manages the privacy settings of the target UE, the decision at step 305 will be negative and the GMLC 212 sends an enquiry message 502 at step 306 to the HLR/HSS 206. The GMLC 212 receives, at step 307, a response message 503 from the HLR/HSS 206, indicating that GMLC 202 is the privacy management node of the target UE terminal 205. Therefore, the GMLC 212 makes a negative decision at step 308 and proceeds to step 325 (Fig. 2C) to send a location request 504 to the GMLC 202. This location request may contain client information such as the display format of location information and functions supported by the client terminal. The GMLC 202 receives this location request 504 at step 301 and makes an affirmative decision at step 302 and proceeds to step 309 to verify the authentication of GMLC 212. If the GMLC 212 is verified (step 310), flow proceeds to step 311 to perform a privacy check 505 on the received location information.

[0030] Once the privacy check 505 has been performed (step 311) and conformance indicated (step 312), the GMLC 202 sends an enquiry message 506 (step 313) to the HLR/HSS 206 for requesting it to respond with a message 507 containing the identity of an SGSN/MSC that manages the RAN 204 where the target UE is connected (step 314). A location request 508 is sent from the GMLC 202 (step 315) to the SGSN/MSC 203. In response to the location request 508, the SGSN/MSC 203 begins to process location estimation by collaborating with the RAN 204 and the target UE terminal

205 (as indicated by an event 509) and transmits the location information of the target UE 205 in a response message 510 to the GMLC 202. The location information contained in the response message 510 is processed according to the UE's privacy settings and a privacy check 511 is performed at step 317 and checked against the UE's privacy settings for conformance (step 318). Flow proceeds from step 318 to step 321. Since the original location request has been received from the GMLC 212, the GMLC 202 makes an affirmative decision at step 321 and proceeds to step 324 to send the location information in a message 512 to the GMLC 212. Following the transmission of the location request 504, the GMLC 212 has been waiting for the location response at step 326. On receiving the message 512, the GMLC 212 proceeds to step 322 to process the received location information according to the preference settings of the client terminal 211 and transmits the processed location information in a message 513 to the client terminal 211 (step 323).

[0031] It will be seen from the foregoing description that enhanced privacy protection is achieved since privacy check is performed on location information before the client terminal is notified of location information.

[0032] Further, the client terminal dependent processes are handled by a GMLC which has received a location request from the client terminal, while the target UE-privacy dependent processes are handled by a GMLC which maintains the privacy settings of the target UE terminal. As a result, the home and external networks can jointly operate in an efficient manner to process a location request received from a client terminal.

[0033] According to variations of the present invention, location information of a target UE terminal can be obtained at periodic intervals.

[0034] A flowchart shown in Fig. 5 is a modification of the flowchart of Fig. 2C. In Fig. 5, a timer is started at step 330 immediately following the transmission of a location request from the requesting GMLC to a home GMLC (step 325). After receiving location-information from the home GMLC (step 326), flow proceeds to step 331 to process the received location information according to the preference settings of the client terminal and transmits the processed location information to the client terminal at step 332, in a manner identical to steps 322 and 323. The requesting GMLC checks to see if the timer has reached its time-out period. If this is the case, flow proceeds to step 334 to check to see if the transmission of a location request has been repeated a predetermined number of times. If not, flow returns to step 325 to send the next location request to the home GMLC. When the transmission of a location request have been repeated the predetermined number of times, flow advances to the end of the routine.

[0035] A sequence diagram of Fig. 6 illustrates a series of events that occur when the requesting GMLC operates according to the routine of Figs. 2A, 2B and 5. In Fig. 6, parts corresponding in significance to those of

Fig. 4 are marked with the same numerals. Therefore, events proceed in the same manner as those of Fig. 4 until the GMLC 212 transmits the location information 513 to the client terminal 211. When the location request 504 is initially transmitted from the GMLC 212 to the GMLC 202, the timer is started (step 330). Following the initial transmission of location information 513, the timer expires (step 333) and the next location request 504 is transmitted from the GMLC 212 to the GMLC 202. The location information is repeatedly produced and transmitted to the client terminal until the count number of the repetitions attains a predetermined value (step 334).

[0036] Instead of the requesting GMLC, the home GMLC may perform the timing operation. The flowchart of Fig. 2B is modified as shown in Fig. 7A to include step 340 where the timer is started immediately following the transmission of a first location request to the SGSN/MSC at step 315. The flowchart of Fig. 2C is modified as shown in Fig. 7B by the inclusion of steps 341 to 344 following step 321. If the original location request is received from the client terminal, the decision at step 321 is negative and flow proceeds to step 341 to process the location information previously received at step 316 (Fig. 7A) according to the client's settings and the processed location information is transmitted to the client (step 342) in the same way as discussed in connection with steps 322 and 323. Step 343 makes a time-out check on the timer. If the timer has expired, flow proceeds to step 344. If the count number of repetitions is smaller than the predetermined value, flow returns to step 315 (Fig. 7A) to transmit the next location request to the SGSN/MSC.

[0037] A sequence diagram of Fig. 8 illustrates a series of events that occur when the GMLC 202 operates according to the routine of Figs. 2A, 7A and 7B. In Fig. 8, parts corresponding in significance to those of Fig. 4 are marked with the same numerals. Therefore, events proceed in the same manner as those of Fig. 4 until the GMLC 212 transmits the location information 513 to the client terminal 211. When the GMLC 202 transmits a location request to the SGSN/MSC 203 (as event 508) (step 315), the timer is started (step 340). Following the initial transmission of location information 513, the timer expires (step 343) and the next location request is transmitted as event 508 from the GMLC 202 to the SGSN/MSC 203. In this way, the location information is repeatedly produced and transmitted to the client terminal until the count number of the repetitions attains a predetermined value (step 344).

[0038] A further modification of the present invention is shown in Fig. 9 in which parts corresponding in significance to those in Fig. 2B are marked with the same numerals. Fig. 9 differs from Fig. 2B in that it further includes steps 350 to 355. Following the acquisition of the identity of an SGSN/MSC at step 314, an event-triggered location request is sent from the home GMLC to the SGSN/MSC (step 350), requesting the latter to initiate location information processing if an event speci-

fied in the request message (such as when the target UE encounters an inter-cell handover or when the target UE returns to the network) has occurred with respect to the target UE terminal and send the location information back to the home GMLC. Flow proceeds to decision step 351 to determine whether the privacy settings of the target UE terminal has been altered. If this is the case, the home GMLC determines whether the altered settings relate only to location information. If the decision is affirmative, flow proceeds to decision step 316 to wait for location information of the target UE from the SGSN/MSC.

[0039] If the altered privacy settings do not exclusively relate to location information, the decision at step 351 or 352 is negative and the home GMLC proceeds to step 353 to determine whether cancellation of the event-triggered location request is required. If cancellation is not required, flow proceeds to step 316. If cancellation is required, a cancellation request is sent to the SGSN/MSC to cancel the even-triggered location request (step 354) and wait for a cancellation response from the SGSN/MSC (step 355). When a cancellation response is received, flow proceeds to step 327 to send an error message.

[0040] If the routine of Figs. 2A, 2C and 9 is performed to transmit an event-triggered location request from the home GMLC to the SGSN/MSC and an event is actually triggered by the target UE, a series of events similar to that of Fig. 4 may take place as shown in Fig. 10A, in which parts corresponding in significance to those of Fig. 4 are marked with the same numerals. When an event-triggered location request 508 is transmitted from the GMLC 202 to the SGSN/MSC 203 (step 350), the GMLC 202 enters a standby mode waiting for the occurrence of a specified event with respect to the target UE. If there is no alteration in the privacy settings of the target UE terminal until the event occurrence, flow proceeds from step 350 through steps 351, 352 or 353 to step 316 to wait for location information. Meanwhile, a process for producing location information (509) begins when the event occurs, and a location response message 510 is sent from the SGSN/MSC 203 to the GMLC 202. In response to this message, the GMLC 202 performs a privacy check 511 (steps 317, 318).

[0041] If the privacy settings of the target UE have been altered while waiting for the event, a series of events may take place in the location system as shown in Fig. 10B. When an event-triggered location request 508 is transmitted from the GMLC 202 to the SGSN/MSC 203 (step 350), the GMLC 202 enters a standby mode waiting for the occurrence of the event. If the privacy settings of the target UE have been altered while waiting for the event, flow proceeds from step 350 through steps 351, 352 or 353 to step 354 to send a cancellation message 520 to the SGSN/MSC 203. The SGSN/MSC 203 replies with a cancellation response message 512, which is detected at step 355 and an error message is sent to the GMLC 212.

[0042] Since the decision mechanism identifies an event-triggered location request which would be adversely affected by altered privacy settings, the present invention eliminates useless transactions which would otherwise be generated while the system is waiting for an event.

[0043] As shown in Fig. 11, the location system of Fig. 1 is modified to include privacy profile registers (PPR), or privacy managers 207 and 217 to store privacy settings of the UE terminals 205 and 215, respectively. PPRs 207 and 217 are connected to the GMLCs 202 and 212, respectively. In this embodiment, privacy check is performed by collaboration between each GMLC and the associated PPR. When the GMLC 202, for example, performs a privacy check, it sends a request message to the associated PPR 207 that holds the privacy settings of the UE terminal 205. PPR 207 may be entrusted to conduct a privacy check by using the stored settings of the target UE and sends the result of the check to the requesting GMLC. Alternatively, the PPR 207 is requested to send the privacy settings of the target UE to the requesting GMLC and the latter takes responsibility to perform the privacy check by using the transmitted privacy setting.

Claims

1. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request; and
 a gateway (202, 212, 206, 216, 207, 217) for holding privacy settings of the mobile terminals, performing a first privacy check on a location request of the client terminal using the privacy settings of a target mobile terminal specified by the request, transmitting said location request to the positioning system to obtain said location information, and performing a second privacy check on said location information using the privacy settings of said target mobile terminal.

2. A location system comprising:

a plurality of mobile terminals (205, 215);
 a plurality of client terminals (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal

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nal in response to a location request; and a plurality of gateways (202, 212) for maintaining privacy settings of the mobile terminals, each gateway receiving a location request from a client terminal, determining which of the gateways maintains the privacy settings of the specified target mobile terminal, and transmitting the location request to a gateway which maintains the privacy settings of the specified target mobile terminal,
 each gateway, which maintains privacy settings of the specified target mobile terminal, performing a first privacy check on a location request received either from the client terminal or from other gateway using the privacy settings of the specified target mobile terminal maintained in the gateway, transmitting the request to the positioning system to obtain location information of the target mobile terminal, and performing a second privacy check on said location information using the privacy settings maintained in the gateway.

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3. The system of claim 1 or 2, wherein the location request transmitted to the gateway that maintains the privacy settings of the target mobile terminal includes information as to the client terminal indicating functionality of the client terminal.

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4. The system of claim 1, 2, or 3, wherein each of said gateways is arranged to transmit a copy of said request to said positioning system at periodic intervals to obtain a plurality of location information of the target mobile terminal, regardless of whether said request has been received from a client terminal or from other gateway.

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5. The system of claim 1, 2, 3 or 4, wherein each of said gateways is arranged to transmit a copy of said request at periodic intervals to a gateway of an external network if the gateway of the external network maintains the privacy settings of the specified target mobile terminal.

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6. The system of any one of claims 1 to 5, wherein each of said gateways is arranged to transmit a copy of said request at periodic intervals to said positioning system if the gateway maintains the privacy settings of the specified target mobile terminal.

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7. The system of any one of claims 1 to 6, wherein each of said gateways is arranged to:

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transmit an event-triggered location request to said positioning system to obtain location information of the target mobile terminal if a specified event occurs in the target mobile terminal, perform said second privacy check on said lo-

cation information if the privacy settings of the target mobile terminal is not altered before said location information is obtained from the positioning system, and
 5 transmit a cancellation request to said positioning system if the privacy settings of the target mobile terminal is altered before said location information is obtained from the positioning system.

8. The location system of claims 1 to 7, further comprising a plurality of databases (207, 217) for maintaining the privacy settings of the mobile terminals and collaborating with a corresponding one of said gateways to perform said first and second privacy check.

9. The location system of claims 1 to 8, wherein said positioning system comprises a plurality of mobile switching systems, and wherein each of said gateways is connected to one or more of said mobile switching systems.

10. The system of any one of claims 1 to 9, wherein said gateways respectively belong to different networks.

11. The system of claim 9 or 10, wherein said mobile switching systems respectively belong to said different networks.

12. A method of protecting privacy of the location of mobile terminals in a location system which includes a gateway and a positioning system, comprising:

35 a) receiving, at said gateway, a location request from a client terminal specifying a target mobile terminal;

b) performing a first privacy check on the location request using the privacy settings of the specified target mobile terminal;

40 c) transmitting the location request to the positioning system to obtain location information of the target mobile terminal; and

d) performing a second privacy check on said location information using the privacy settings of said target mobile terminal.

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13. The method of claim 12, wherein said location system includes a plurality of gateways for respectively maintaining privacy settings of the mobile terminals and a positioning system,
 50 wherein step (a) further comprises determining which of said gateways maintains the privacy settings of the specified mobile terminal,
 wherein step (b) comprises performing said

5 first privacy check on the location request using the privacy settings maintained in the determined gateway for the specified target mobile terminal, and
 wherein step (d) comprises performing said second privacy check on the measurement result from said positioning system using the privacy settings maintained in the determined gateway for said target mobile terminal.

14. The method of claim 13, wherein said positioning system comprises a plurality of mobile switching systems and wherein each of said gateways is connected to one or more of said mobile switching systems, wherein step (c) further comprises determining which of the mobile switching systems the target mobile terminal is accessible, and transmitting said request to the determined mobile switching system to obtain said location information.

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15. The method of claim 12, 13 or 14, further comprising, following step (d), transmitting a copy of said location request to said positioning system at periodic intervals to obtain a plurality of location information of the target mobile terminal and transmitting the location information obtained for each of the transmitted copy to said client terminal.

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16. The method of claim 12, 13, 14 or 15, wherein step (d) further comprises processing said location information obtained from said positioning system according to privacy settings of said client terminal if the location information conforms to the privacy settings of said target mobile terminal, and transmitting the processed location information to the client terminal.

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17. The method of claim 12, 13, 14, 15 or 16, wherein said location request transmitted to said positioning system is an event-triggered location request to obtain location information of the target mobile terminal if a specified event occurs with respect to the target mobile terminal, and wherein step (d) further comprises performing said second privacy check on the location information if the privacy settings of the target mobile terminal is not altered before the location information is obtained from the positioning system, and transmitting a cancellation request to said positioning system if the privacy settings of the target mobile terminal is altered before the location information is obtained from the positioning system.

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18. A gateway of a location system, wherein the gateway is one of a plurality of gateways of the location system, wherein the gateways respectively maintain privacy settings of the mobile terminals, comprising:

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means for receiving a location request from a

client terminal specifying a target mobile terminal and determining which of said gateways maintains the privacy settings of the specified mobile terminal;

means for performing a first privacy check on the location request using the privacy settings maintained by the gateway for the specified target mobile terminal;

means for transmitting the location request to the positioning system to obtain location information of the target mobile terminal if the request conforms to said privacy settings; and

means for performing a second privacy check on said location information using the privacy settings maintained in the gateway for said target mobile terminal.

19. The system of any one of claims 1 to 11 or 18, wherein said gateway performs said second privacy check if the location request conforms to said privacy settings.

20. The system of any one of claims 2 to 18, wherein each of said gateways which maintains privacy settings of the specified target mobile terminal, performs said second privacy check if the location request conforms to said privacy settings.

21. A location system comprising:

a plurality of mobile terminals (205, 215);

a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;

a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request; and

a plurality of gateways (202, 212) for holding privacy settings of the mobile terminals, transmitting the location request to the positioning system to obtain location information of the target mobile terminal, and performing a privacy check on said location information using the privacy settings of said target mobile terminal.

22. A location system comprising:

a plurality of mobile terminals (205, 215);

a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;

5 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;

10 a plurality of privacy managers (207, 217) for maintaining the privacy settings of the mobile terminals and performing a privacy check using the privacy settings of a target mobile terminal; and

15 a plurality of gateways (202, 212) for transmitting said location request to the positioning system to obtain location information of the target mobile terminal, and requesting the privacy managers to perform a privacy check on the obtained location information.

23. A location system comprising:

20 a plurality of mobile terminals (205, 215);

a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;

a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;

25 a plurality of privacy managers (207, 217) for maintaining the privacy settings of the mobile terminals and performing a privacy check using the privacy settings of a target mobile terminal; and

30 a plurality of gateways (202, 212) for requesting said privacy manager, which maintains the privacy settings of a target mobile terminal specified by the request, to perform a first privacy check on a location request of the client terminal, transmit said location request to the positioning system to obtain location information of the target mobile terminal, and requesting said means to perform a second privacy check on the location information of the target mobile terminal.

24. A location system comprising:

35 a plurality of mobile terminals (205, 215);

a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;

40 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;

45 a plurality of gateways (202, 212) for maintaining privacy settings of the mobile terminals, each gateway receiving a location request from a client terminal, determining which of the gateways maintains the privacy settings of the spec-

ified target mobile terminal, and transmitting the location request to a gateway which maintains the privacy settings of the specified target mobile terminal,
 each gateway, which maintains the privacy settings of the specified target mobile terminal, performing a first privacy check on a location request received either from the client terminal or from other gateway using the privacy settings of the specified target mobile terminal, transmitting the request to the positioning system to obtain location information of the target mobile terminal, and performing a second privacy check on said location information using the privacy settings maintained in the gateway.

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25. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;
 a plurality of gateways (202, 212) for maintaining privacy settings of the mobile terminals, each gateway receiving a location request from a client terminal, determining which of the gateways maintains the privacy settings of the specified target mobile terminal, and transmitting the location request to a gateway which maintains the privacy settings of the specified target mobile terminal,
 each gateway, which maintains the privacy settings of the specified target mobile terminal, transmitting said location request to the positioning system to obtain location information of the target mobile terminal, and performing a privacy check on the location information of the target mobile terminal using the privacy settings maintained in the gateway.

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26. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;
 a plurality of privacy managers (207, 217) for maintaining the privacy settings of the mobile terminals and performing a privacy check using the privacy settings of a target mobile terminal;

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and

a plurality of gateways (202, 212),
 each gateway receiving a location request from a client terminal, determining which of the gateways is associated with the privacy manager which maintains the privacy settings of the specified target mobile terminal, and transmitting the location request to the determined gateway,
 each gateway, associated with the privacy manager which maintains the privacy settings of the specified target mobile terminal, requesting the associated means to perform a first privacy check on a location request of the client terminal, transmitting the location request to the positioning system to obtain location information of the target mobile terminal, and requesting the associated means to perform a second privacy check on the obtained location information using said privacy settings.

27. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;

a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;
 a plurality of privacy managers (207, 217) for maintaining the privacy settings of the mobile terminals and performing a privacy check using the privacy settings of a target mobile terminal; and

a plurality of gateways (202, 212),
 each gateway receiving a location request from a client terminal, determining which of the gateways is associated with the privacy manager which maintains the privacy settings of the specified target mobile terminal, and transmitting the location request to the determined gateway,

each gateway, associated with the privacy manager which maintains the privacy settings of the specified target mobile terminal, requesting the associated means to perform a first privacy check on a location request of the client terminal, transmitting the location request to the positioning system to obtain location information of the target mobile terminal, and requesting the associated means to perform a second privacy check on the obtained location information using said privacy settings.

28. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;
 a home register (206, 216) which stores identity of a gateway which maintains privacy settings of the mobile terminals; and
 a plurality of gateways (202, 212) for maintaining privacy settings of the mobile terminals, each gateway receiving a location request from a client terminal, sending an enquiry message to the home register to obtain the identity of the gateway if said identity is not known, and transmitting the location request to a gateway identified by the obtained identity.

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29. A location system comprising:

a plurality of mobile terminals (205, 215);
 a client terminal (201, 211) for transmitting a location request specifying a target mobile terminal;
 a positioning system (203, 204, 213, 214) accessible to said mobile terminals for producing location information of the target mobile terminal in response to a location request;
 a home register (206, 216) which stores identity of a gateway which maintains privacy settings of the mobile terminals;
 a privacy manager (207, 217) for maintaining privacy settings of the mobile terminals and performing a privacy check using the privacy settings of a target mobile terminal;
 a home register (206, 216) for maintaining identity of a gateway which accesses the privacy manager that maintains privacy settings of the mobile terminals; and
 a plurality of gateways (202, 212), each gateway receiving a location request from the client terminal, sending a message to the home register that stores the identity of the gateway which accesses the a privacy manager which maintains privacy settings of the target mobile terminal to obtain the identity of the gateway if the identity is not known, and transmitting the location request to a gateway identified by the obtained identity.

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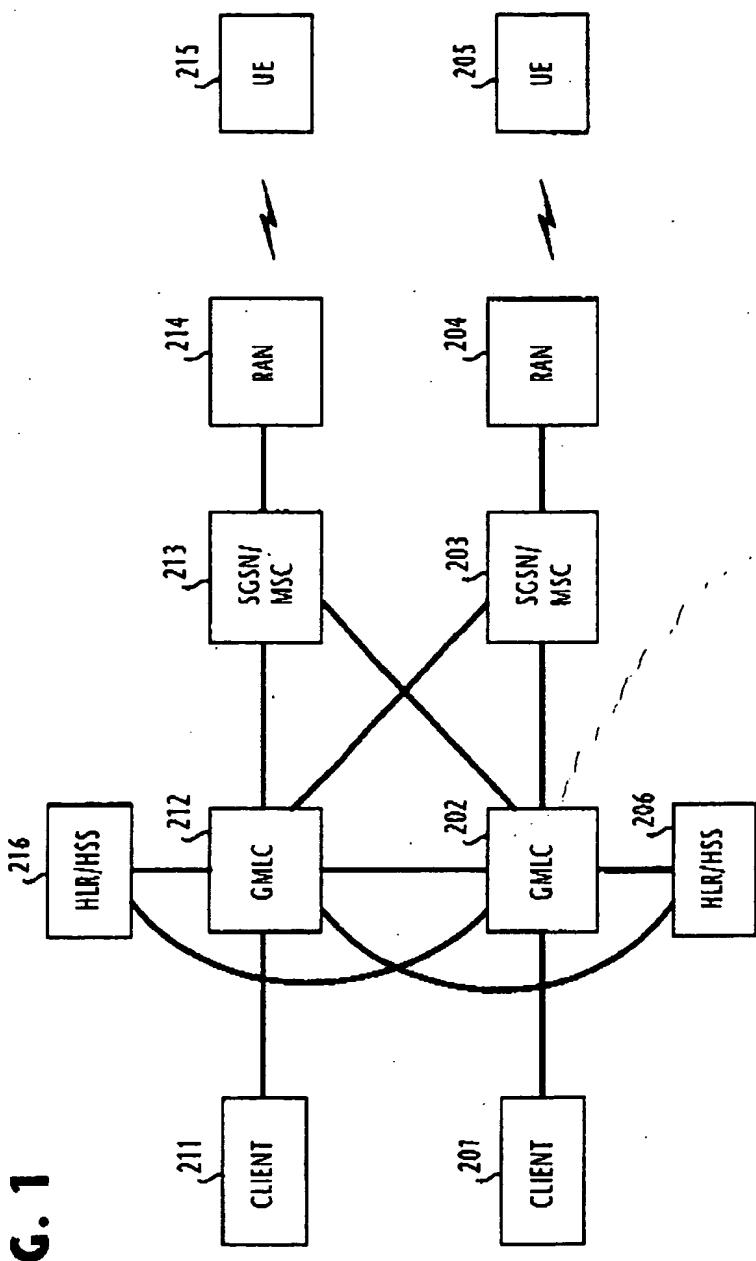
30. A location method, comprising:

receiving a location request from a client terminal;
 obtaining location information of a target mobile terminal specified by the location request; and
 performing a privacy check on the location in-

formation of the target mobile terminal.

31. A location method, comprising:

transmitting a location request to a location system, whereby the location system obtains location information of a target mobile terminal specified by the location request and performs a first privacy check before obtaining the location information and a second privacy check after obtaining the location information; and
 receiving the location information from the location system after the first and second privacy checks.

FIG. 1

LEGEND: GMLC = GATEWAY MOBILE LOCATION CENTER

HLR/HSS = HOME LOCATION REGISTER/HOME SUBSCRIBER SERVER

SGSN/MSC = SERVING GPRS (GENERAL PACKET RADIO SERVICE) SUPPORT NODE/MOBILE SERVICES SWITCHING CENTER

RAN = RADIO ACCESS NETWORK

UE = USER EQUIPMENT

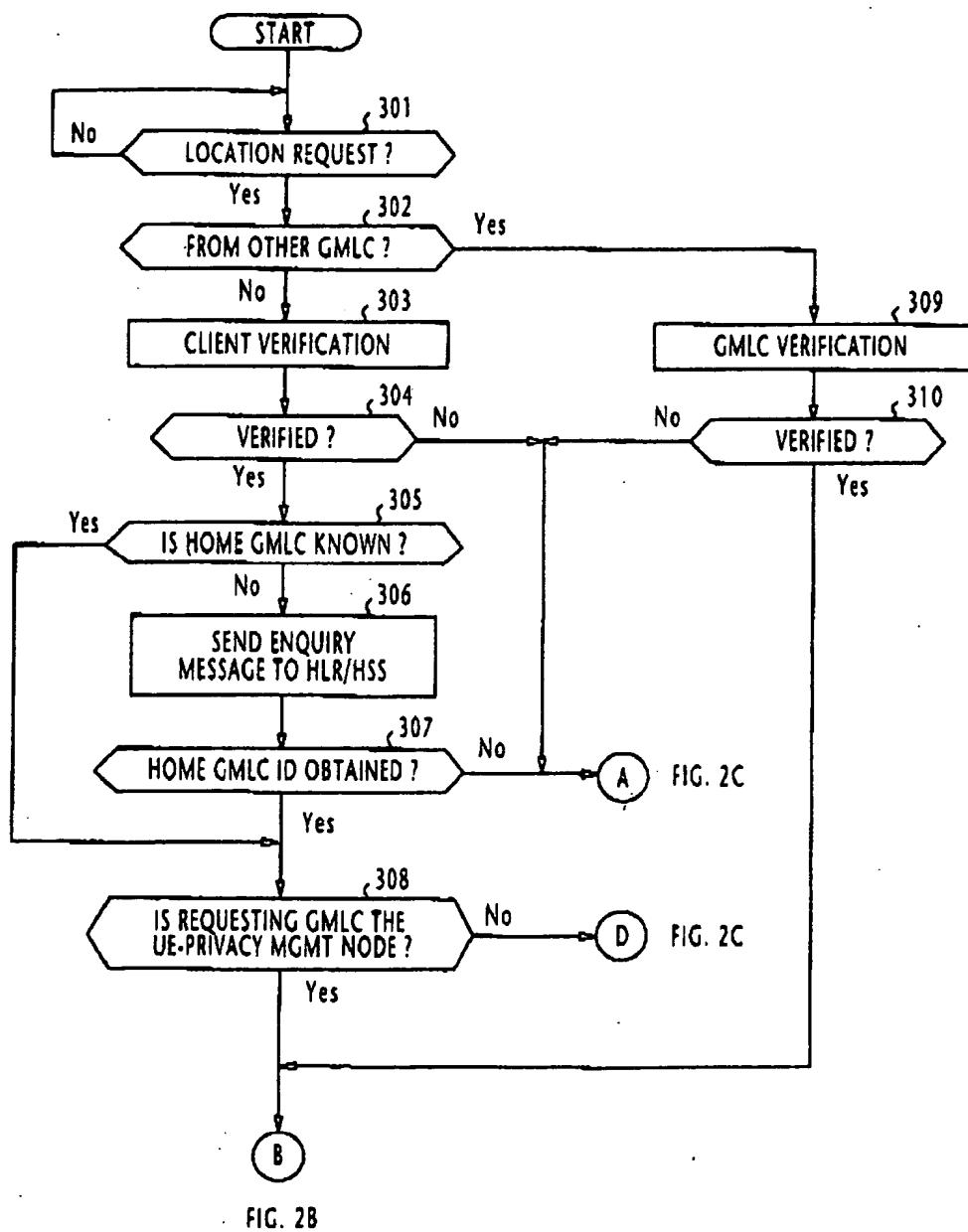
FIG. 2AGATEWAY MOBILE LOCATION CENTER (GMLC)

FIG. 2B

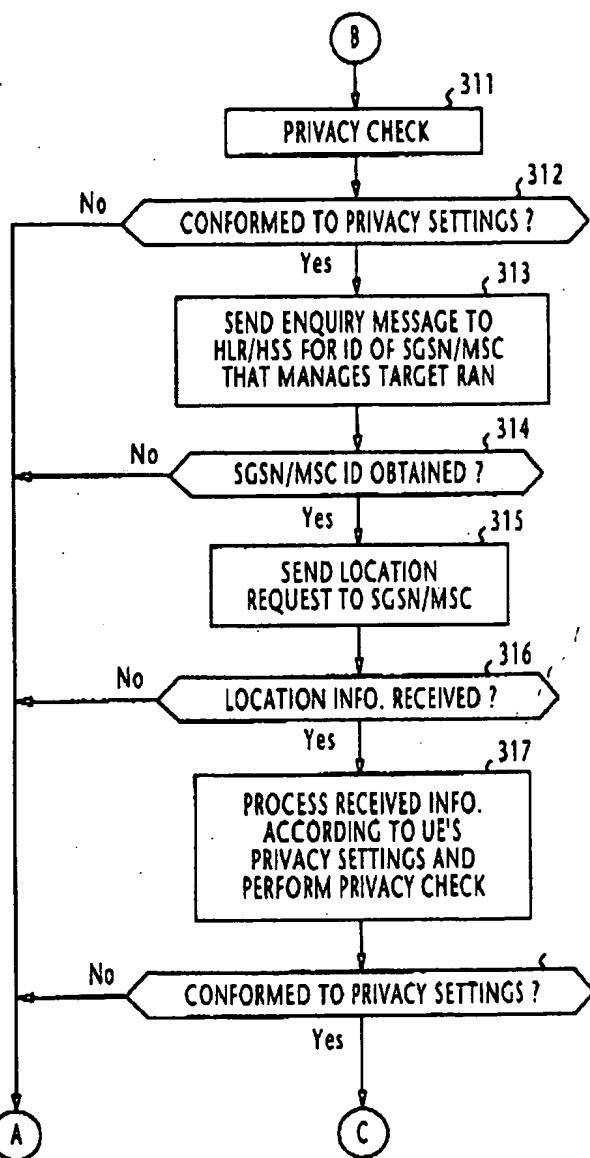
GATEWAY MOBILE LOCATION CENTER (GMLC)

FIG. 2C

FIG. 2C

FIG. 2C

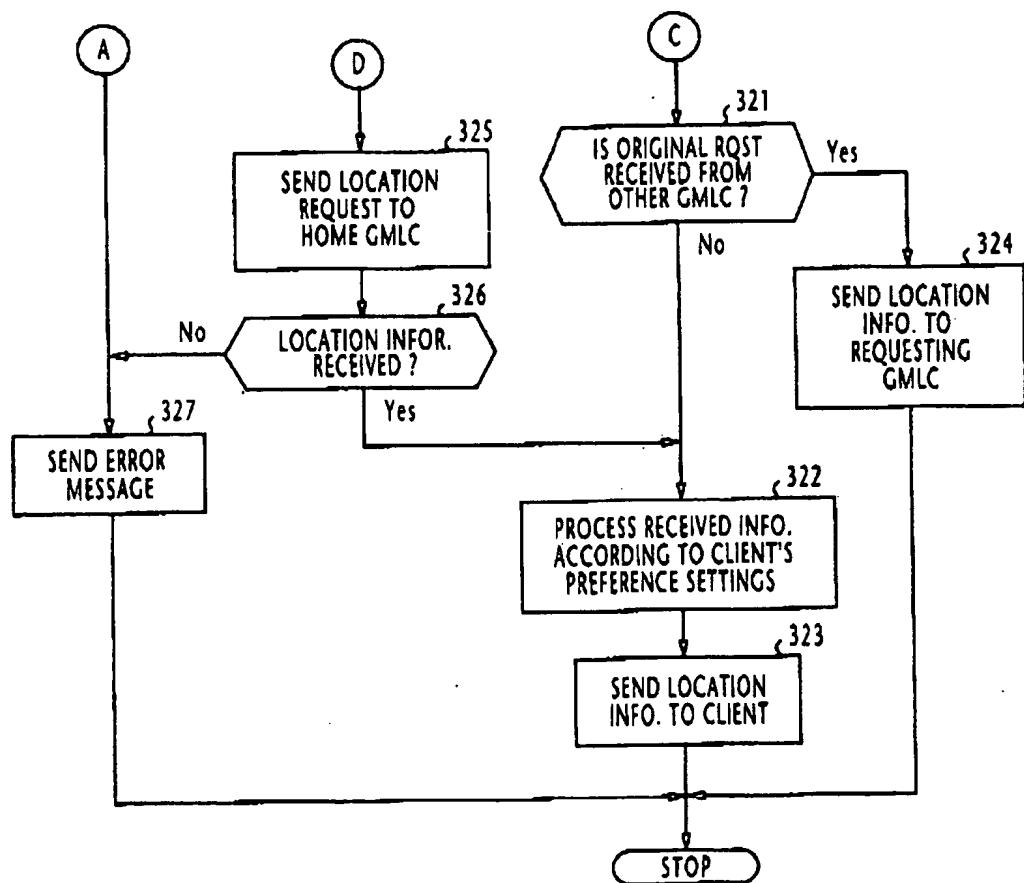
GATEWAY MOBILE LOCATION CENTER (GMLC)

FIG. 3

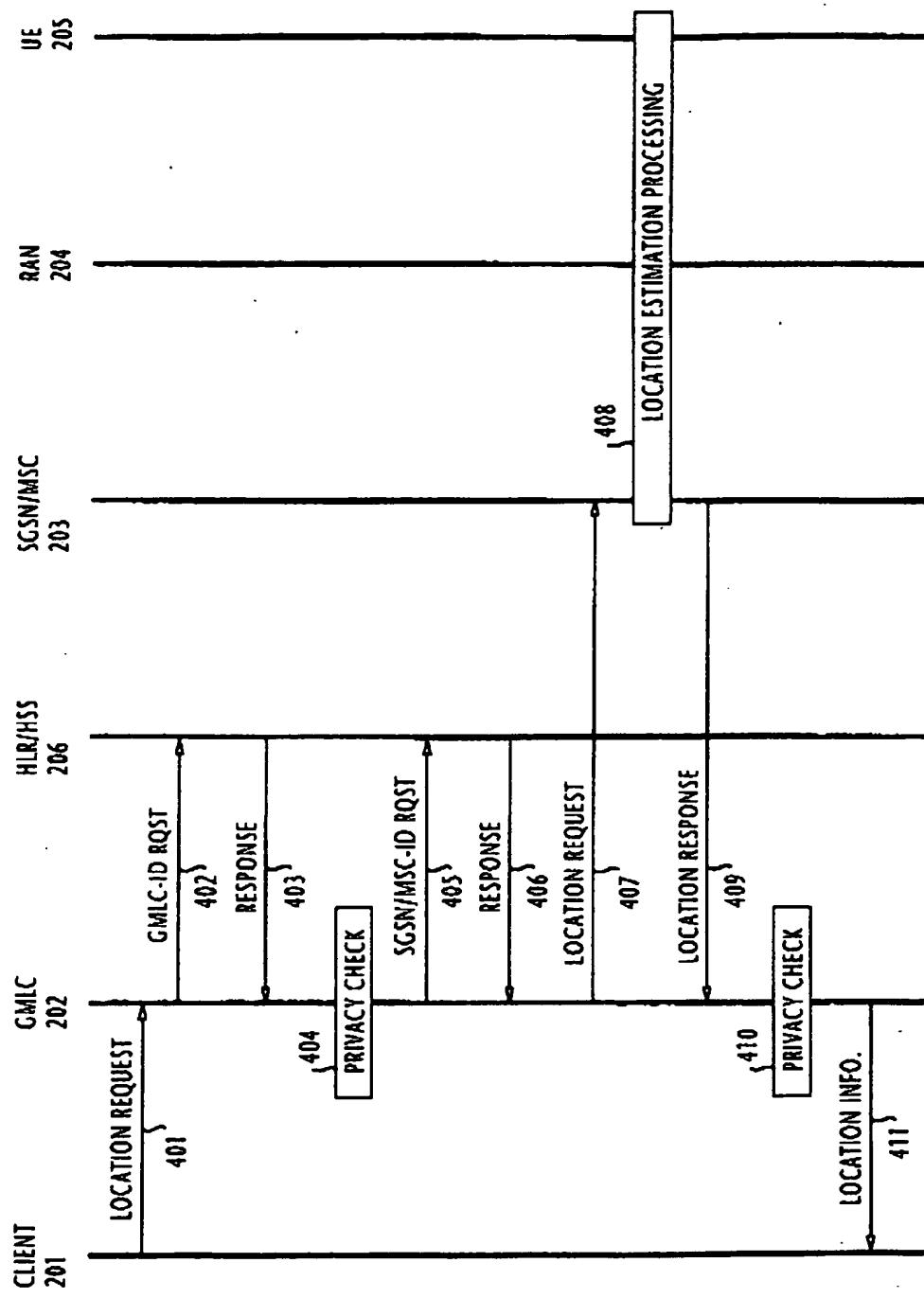


FIG. 4

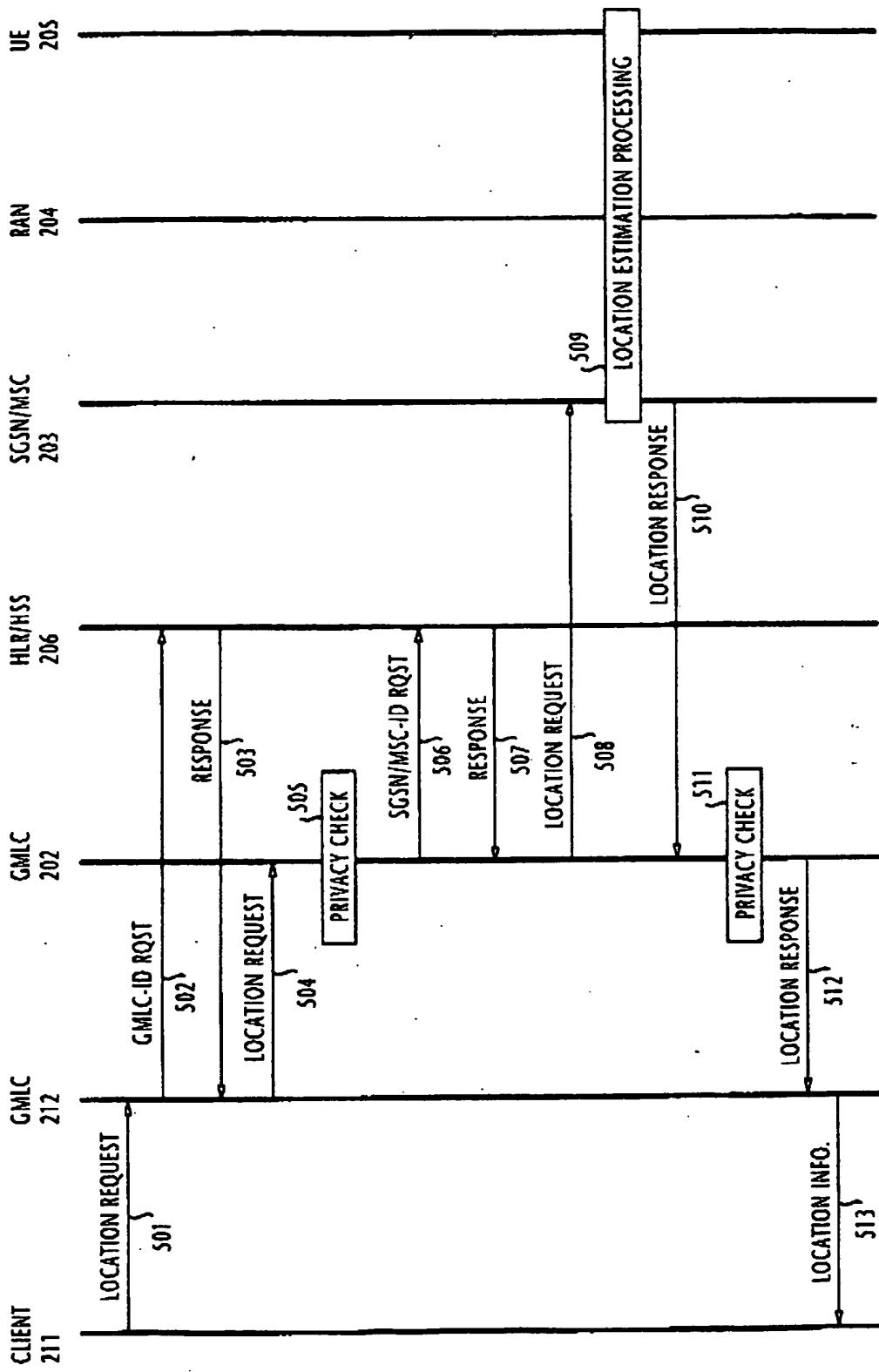


FIG. 5
GATEWAY MOBILE LOCATION CENTER (GMLC)

FIG. 2A

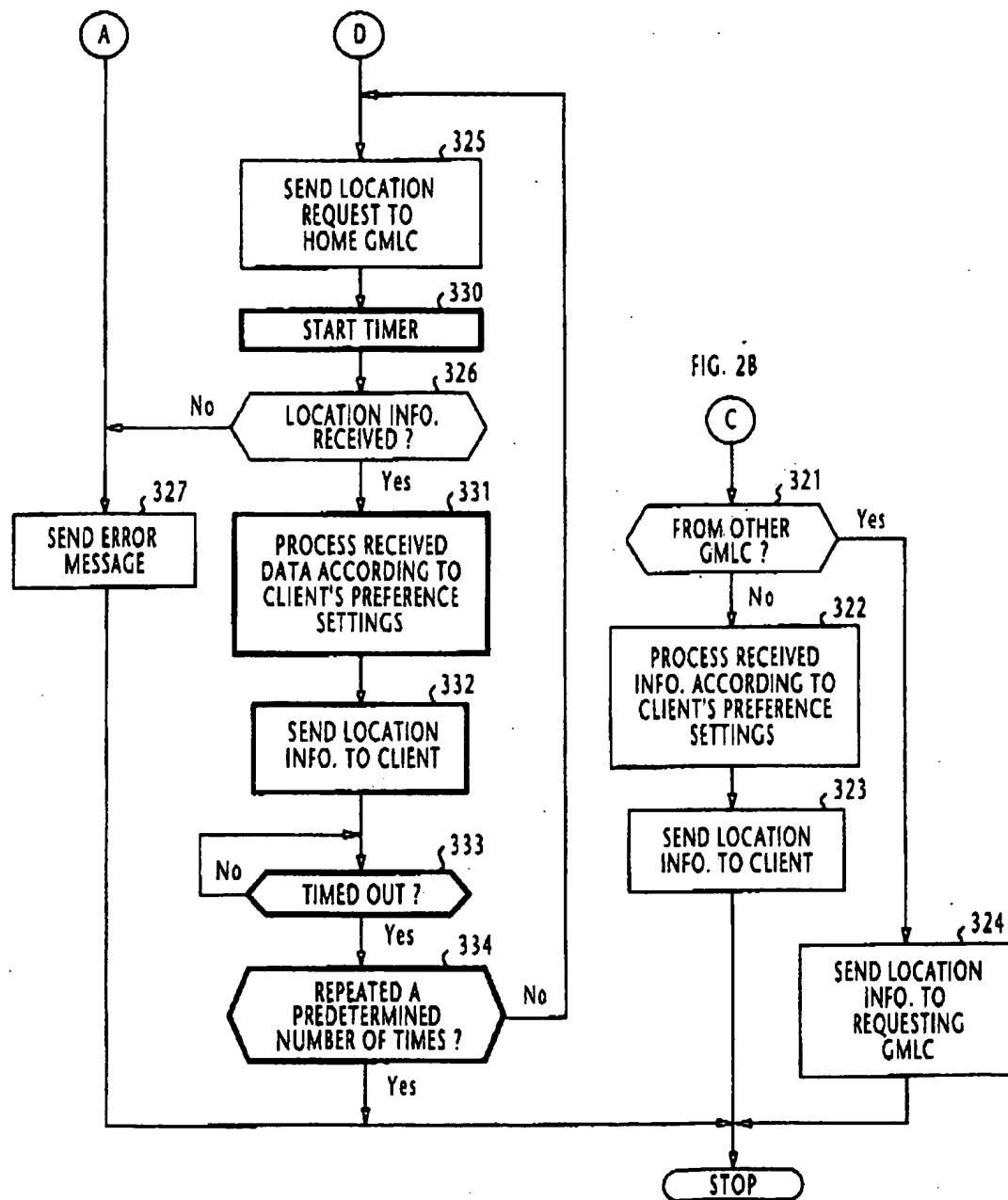


FIG. 2A

FIG. 2B

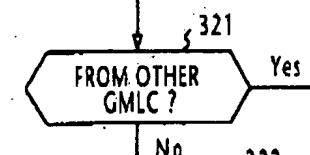


FIG. 6

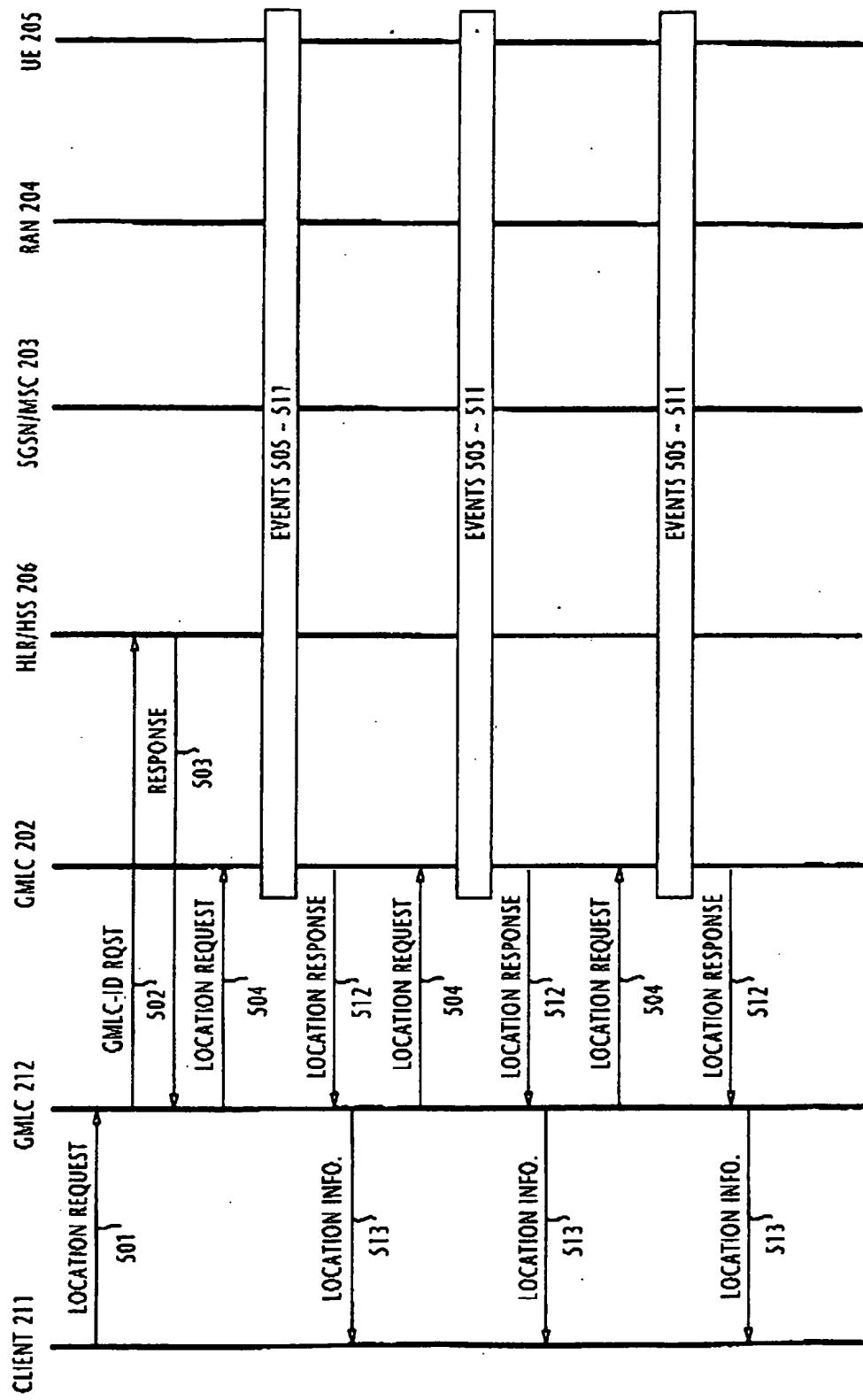


FIG. 7A
GATEWAY MOBILE LOCATION CENTER (GMLC)

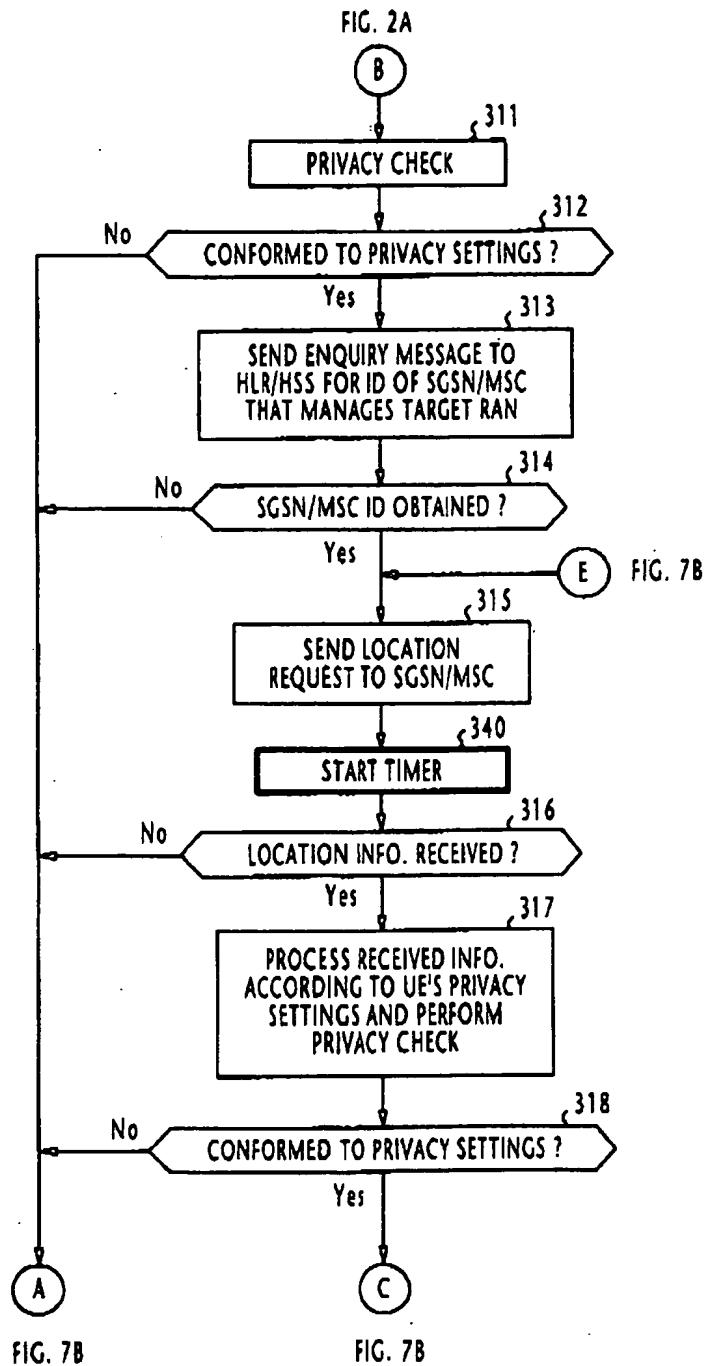


FIG. 7B
GATEWAY MOBILE LOCATION CENTER (GMLC)

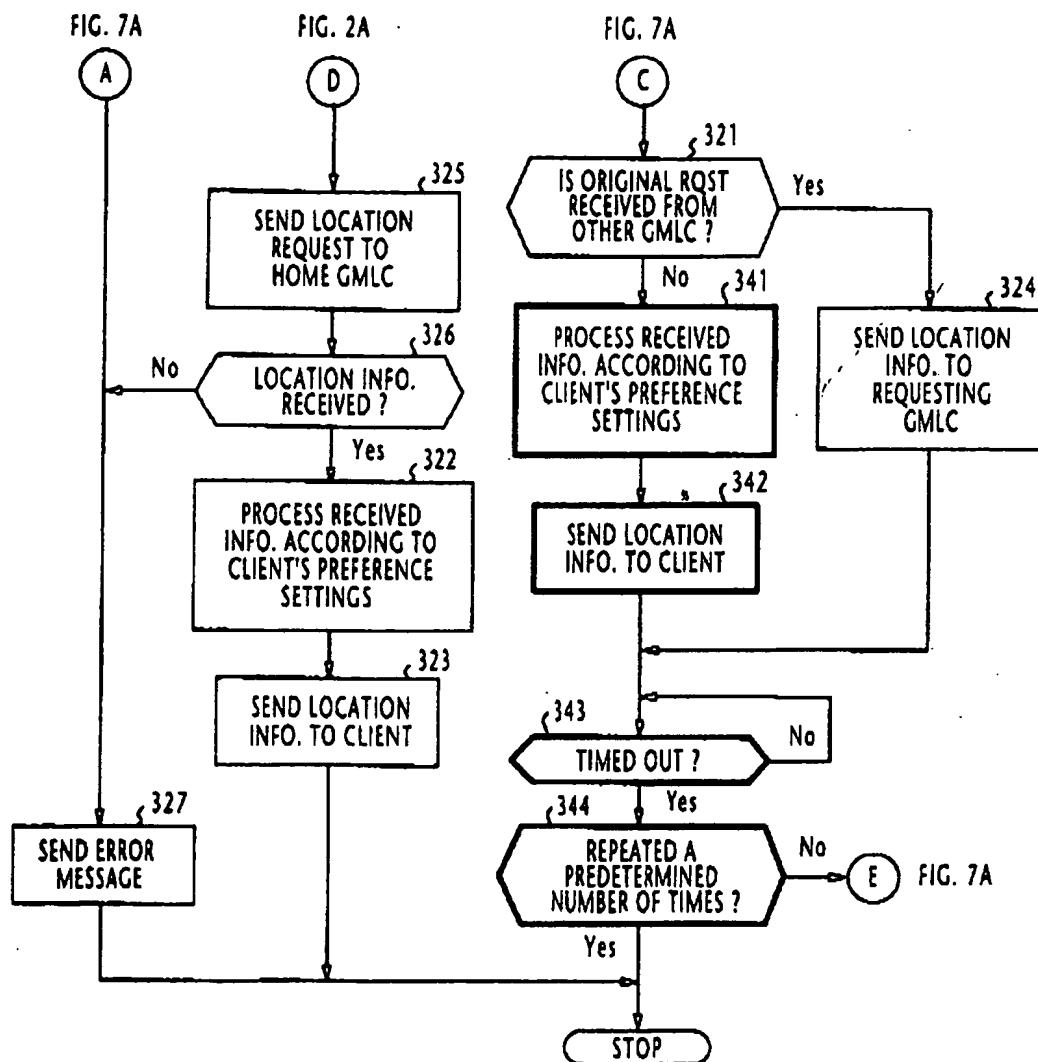


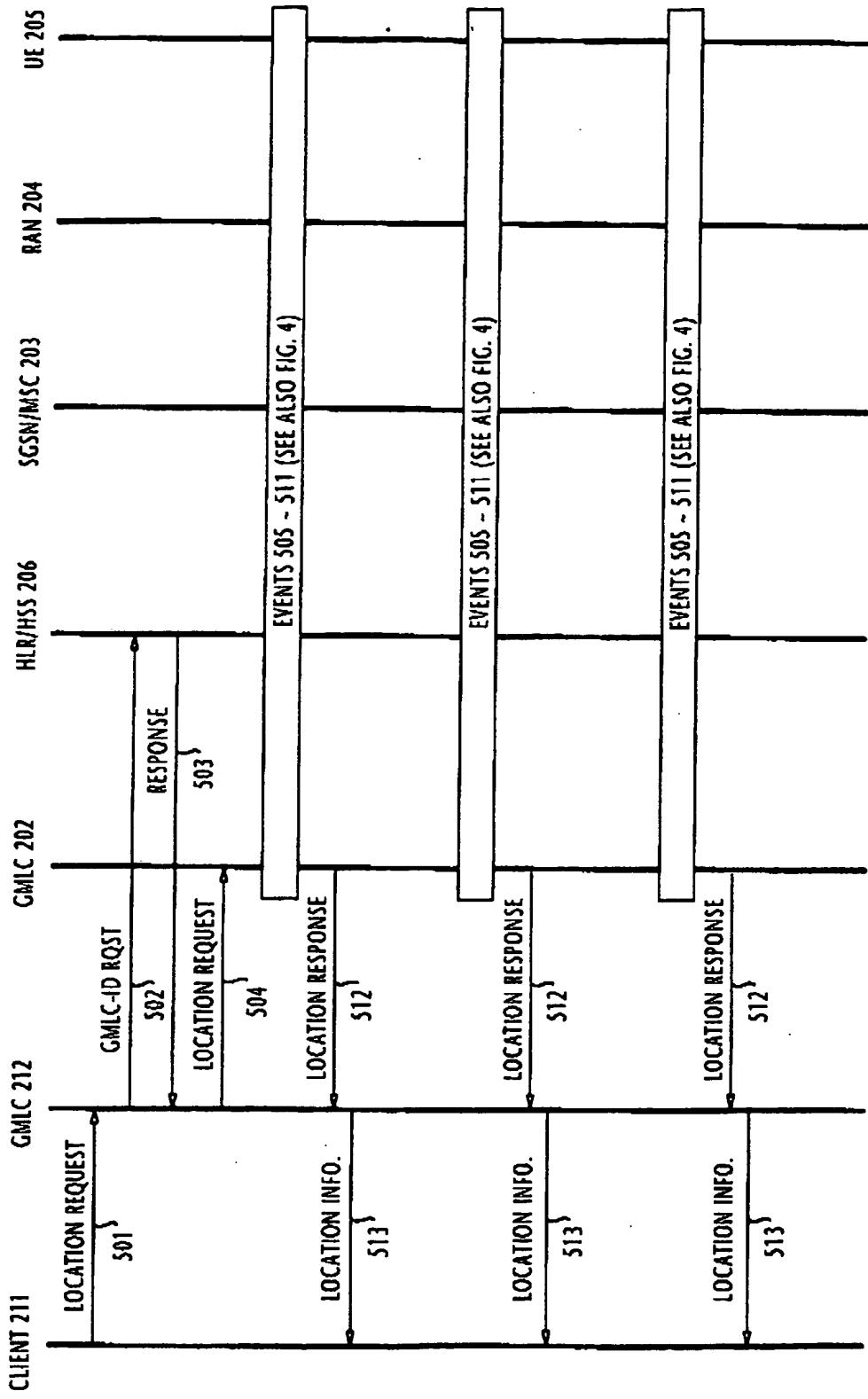
FIG. 8

FIG. 9

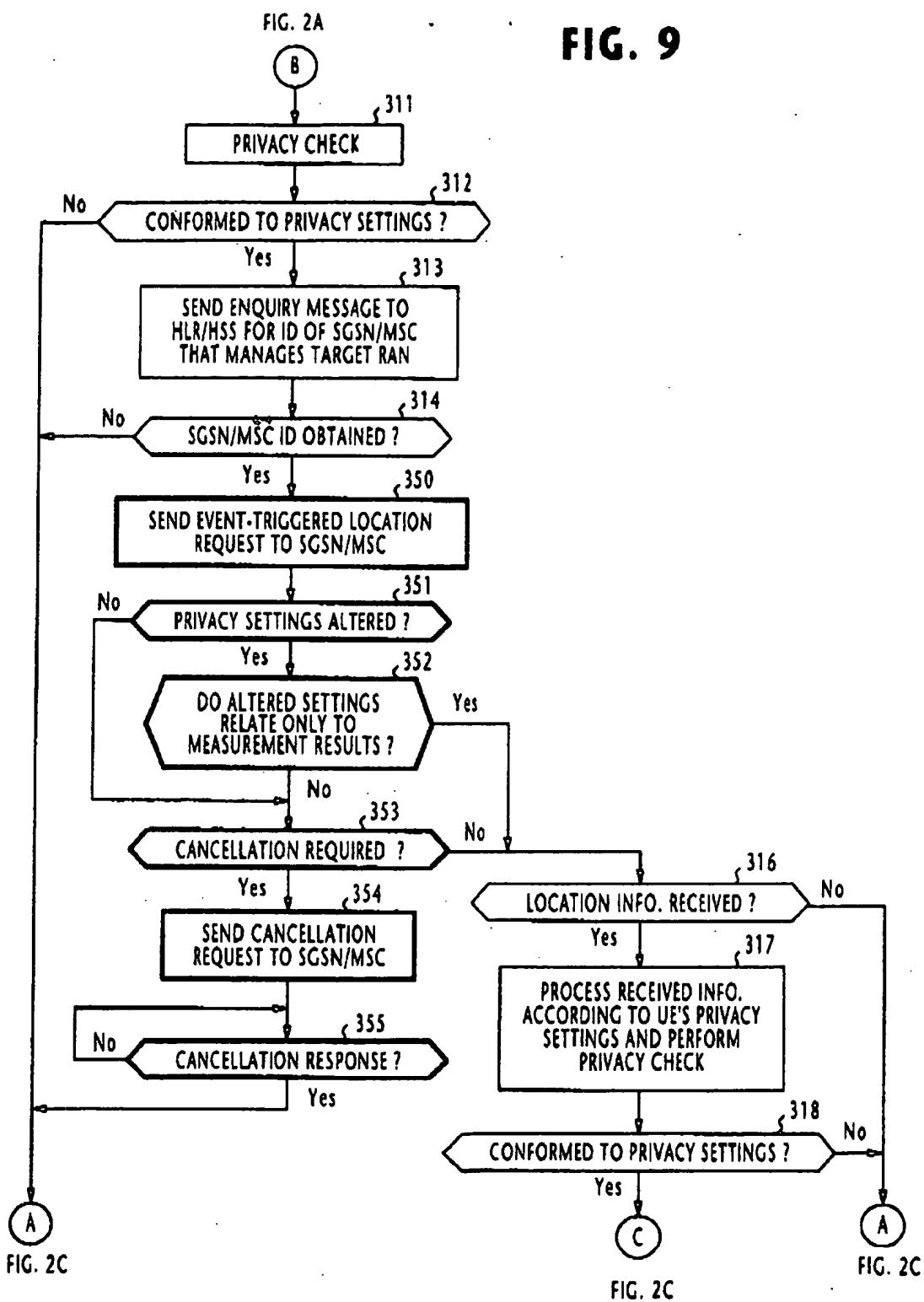


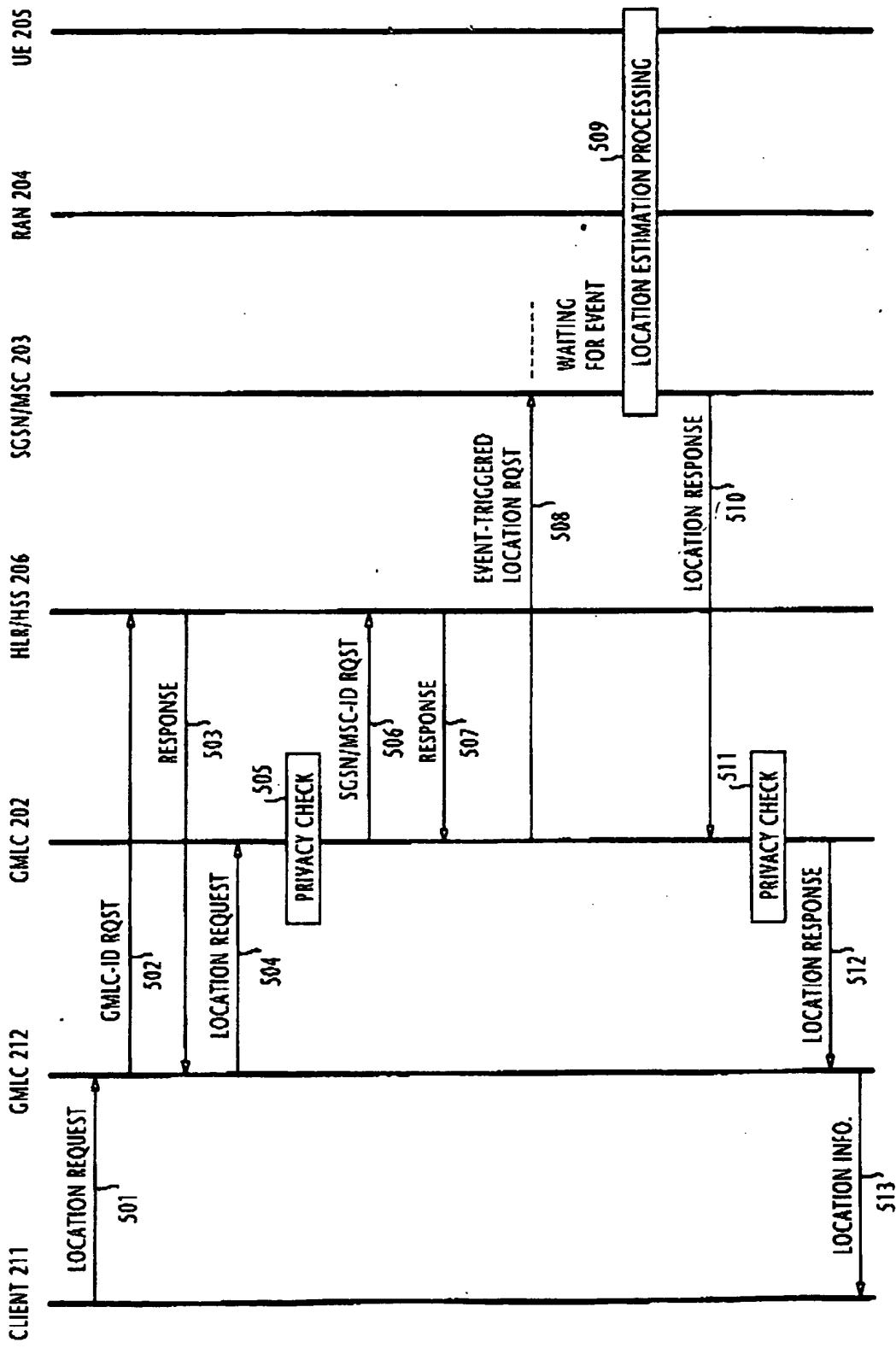
FIG. 10A

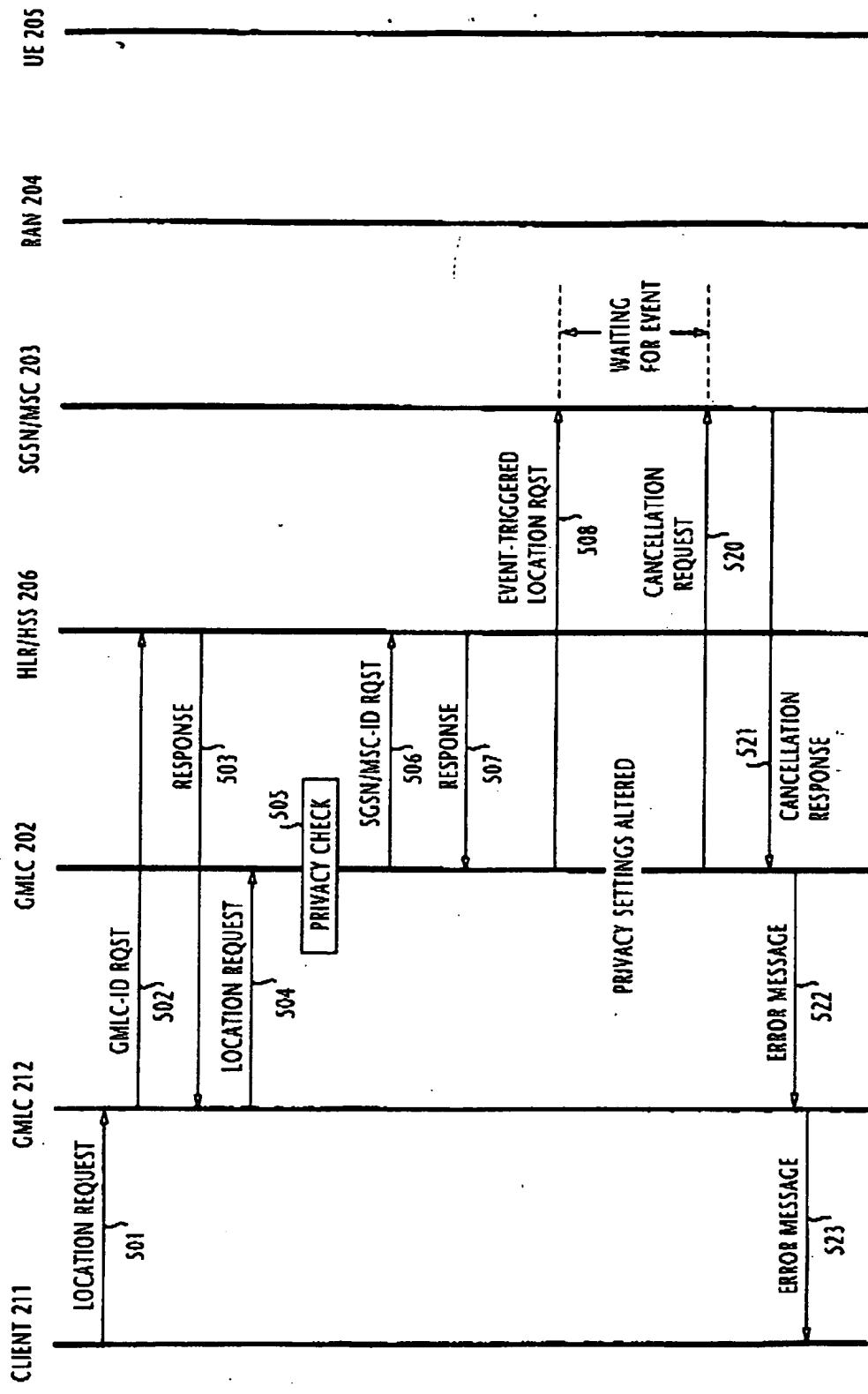
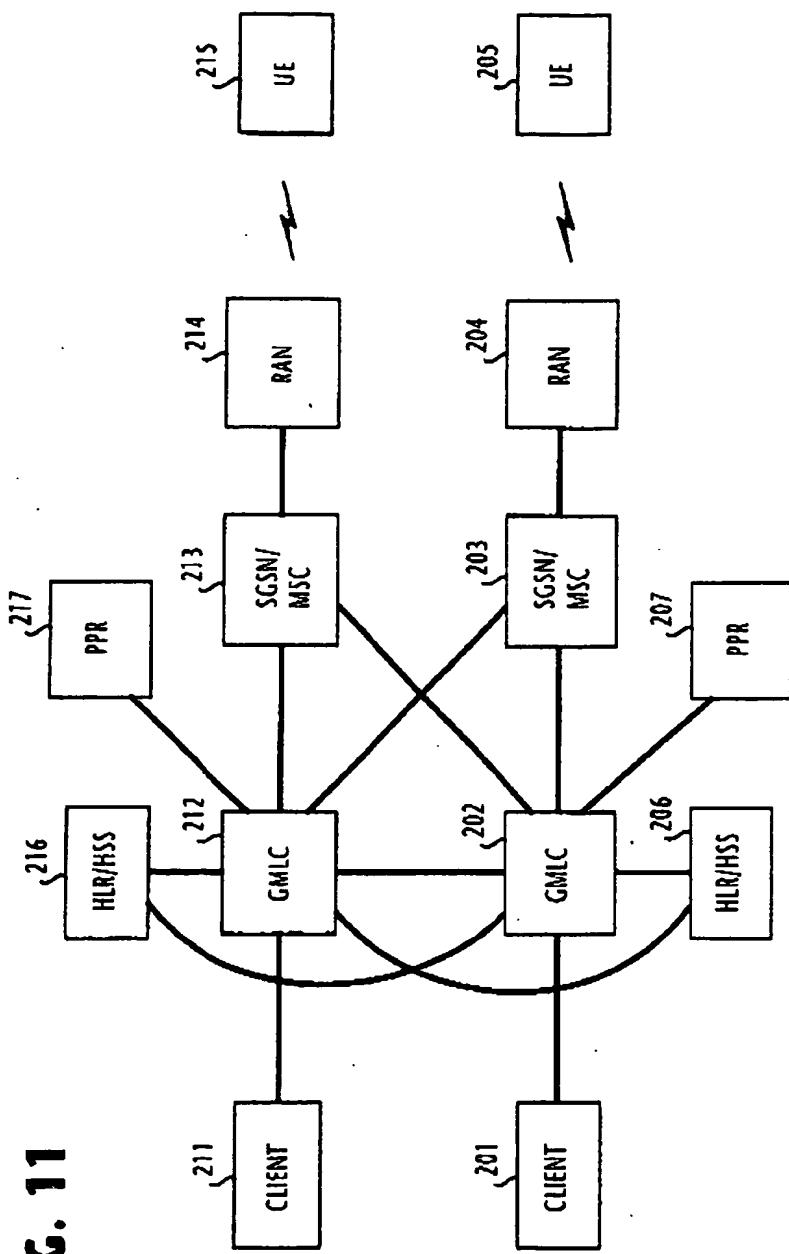
FIG. 10B

FIG. 11

LEGEND: GMIC = GATEWAY MOBILE LOCATION CENTER

HLR/HSS = HOME LOCATION REGISTER/HOME SUBSCRIBER SERVER

SGSN/MSC = SERVING GPRS (GENERAL PACKET RADIO SERVICE) SUPPORT NODE/MOBILE SERVICES SWITCHING CENTER

RAN = RADIO ACCESS NETWORK

UE = USER EQUIPMENT

PPR = PRIVACY PROFILE REGISTER

FIG. 12

PRIOR ART

